TECHNICAL MEMORANDUM NO. 74-15

UNDERWATER ADHESIVES STUDY

USALWL Task 05-CA-74
Work Assignment No. 4
Contract No. DAAD05-74-C-0723

By

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Under Work Assignment No. 4 of Contract DAAD05-74-C-0723 by The Franklin Institute Research Laboratories (FIRL) for the U.S. Army Land Warfare Laboratory, three commercially available adhesives were evaluated for underwater use. Of the three items tested for quick and effective bonds (lap shear) the National Cash Register Company's (NCR) product appears to have the most promise; however, additional efforts will be required for formula improvement and for a device to apply the compound to mission substrates.

FOREWORD

This report is submitted in compliance with contractual requirements as directed by the U.S. Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, under Contract No. DAADO5-74-C-0723. Mr. J. L. Baer, Chief of Applied Chemistry Branch, served as Technical Supervisor for the work, and we would like to acknowledge his assistance during the project.

Principal Investigators for the program at The Franklin Institute Research Laboratories were Messrs R. Hollinger and E. Thelen.

1. INTRODUCTION

A need exists within DOD agencies for an adhesive with special aquatic properties. This feasibility program was to evaluate several adhesives/epoxies and determine their effectiveness as suitable underwater bonding agents.

2. OBJECTIVE

This letter report describes the work carried out under Task No. 4, with the objective being to investigate four commercial adhesives. The only requirement being a relatively high shear strength under water with the shortest possible time (seconds).

3. ADHESIVES

Four adhesives were to be used in the evaluation:

a. Devcon - an epoxy adhesive

b. F-88 - an adhesive used in dental applications

c. NCR - an adhesive developed by National Cash Register Company under government contract

d. Sinmast - a product of Sinmast A.G. used for repair and patching of underwater structures and ship halls.

Repeated attempts to obtain the Sinmast product from the American dealer gave no result. This makes it appear that the product is not readily available. In lieu of tests with the Sinmast adhesive, a second mixture of F-88 adhesive which was said to give more rapid setting was used.

4. SUBSTRATES

Four substrates were selected for use with each of the adhesives. The materials used were:

a. Steel - mild steel sheet

b. Aluminum - bare aluminum alloy sheet

c. Polyester - polymethylmethacrylate sheet

d. Wood - exterior grade plywood

5. METHOD OF TEST

The substrate materials were conditioned by immersion in simulated sea water prepared using the standard mixture of salts for salt water fish aquaria. The period of immersion was at least 24 hours with most times nearer 48 hours. The adhesives were mixed in air, but were applied to the conditioned substrates under water at the time lap joints were prepared. An area of six square inches of contact surface comprised the standard lap joint. Times for cure are noted from the time of application of the adhesive. Mixing time for most of the adhesives was approximately 30 seconds except for the NCR adhesive as noted later.

6. RESULTS OF TESTS

Results of lap shear tests are noted for the various adhesives with four different substrates and cure times in the table below. Shear strengths are shown in pounds force for a six square inch contact area of the test adhesive and substrate. The earliest development of shear strength is shown by the NCR adhesive followed by the F88 4:1 mixture.

TABLE OF LAP SHEAR TEST RESULTS

	Time in Minutes vs Shear Strength - lbs							
	.5	1.0	2.0	3.0	4.0	5.0	45	270
Polymethylmethacrylate								
Devcon	-	-	-	-	-	-	6.0	+100
F88 3:1	-	-	8.0	13.0	-	+100	-	-
F88 4:1	-	-	15.5	43.0	-	+100	-	-
NCR	8.3	16.5	67.5	-	-	-	-	-

TABLE OF LAP SHEAR TEST RESULTS (Cont.)

	Time in Minutes vs Shear Strength							
	.5	1.0	2.0	3.0	4.0	5.0	45	270
Wood								
Devcon	-	-	-	-	-	-	20.0	62.5
F88 3:1	-	0	0	12.0	-	40.0	-	-
F88 4:1	-	-	0	0	-	60.5	-	-
NCR	27.0	30.3	38.0	-	-	-	-	-
Aluminum								
Devcon	-	-	-	-	-	-	7.3	67.5
F88 3:1	-	-	20.0	14.0	-	-	-	-
F88 4:1	-	-	8.5	24.5	-	-	-	-
NCR	26.0	27.0	80.0	-	-	-	-	-
Steel								
Devcon	-	-	-	-	-	-	1.8	+100
F88 3:1	-	-	7.0	12.0	-	+100	-	-
F88 4:1	-	-	13.0	32.0	+100	+100	-	-
NCR	16.0	26.0	82.5	-	-	-	-	-

7. COMMENTS ON ADHESIVES AND RECOMMENDATIONS

The Devcon adhesive mixes and applies easily but is slow curing. This adhesive should not be considered further.

F-88 adhesive mixes and applies easily and gives fairly good early strength in the range of 2 to 3 minutes after application. The cure is rapid but not so rapid as to cause handling difficulty. The adhesive deserves secondary consideration for underwater use.

The NCR adhesive gives the highest early strength and is the adhesive of of choice for this application. Several factors affect its use and should be the object of further investigation:

a. The two component adhesive system must be mixed and applied rapidly. The initial setting of this adhesive is not developed smoothly, but occurs over an interval of 2 to 3

seconds. The system remains liquid for only about 40 seconds from time of first contact of the components, after which the system gels rapidly. Mixing time is restricted to 10-15 seconds followed by immediate application. An application device must be developed which allows rapid mixing and application of the adhesive.

b. Once applied, the system cannot be disturbed during gel formation and subsequent cure. Disturbance of the system causes breaks in the gel structure and full strength is not developed.

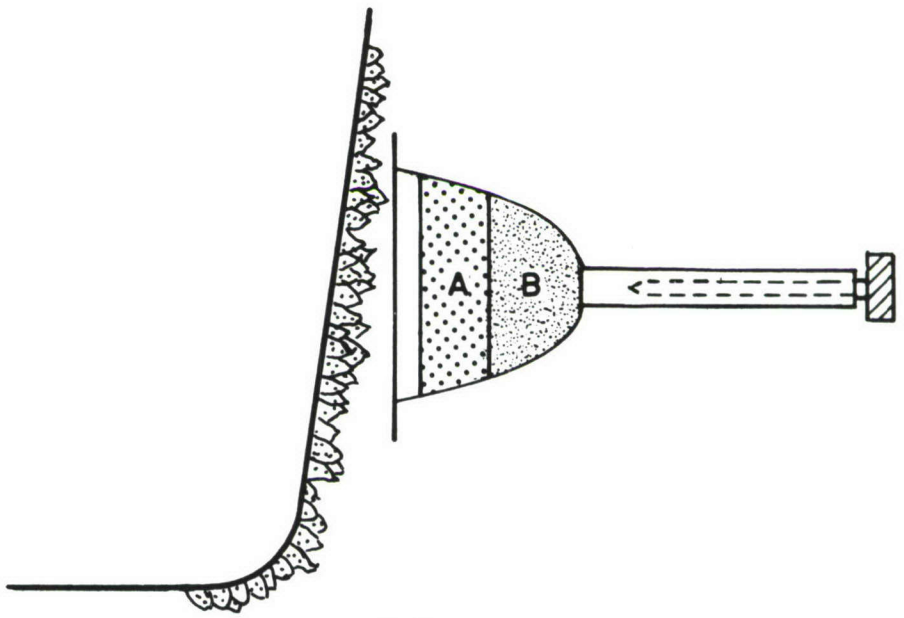
c. The system is lighter than salt water and must be applied to the substrate in a manner which will prevent the adhesive from floating away from the surface of the substrate. A dense filler might be incorporated into the adhesive providing such filler does not affect the cure rates or final strength.

d. The estimated cost of a pound of NCR adhesive for mission use would be approx. $5.00.

8. APPLICATOR CONCEPTS

Two possible concepts for applying the underwater adhesive are sketched on the following page. In concept No. 1, the adhesive components A and B are separated and protected by membranes. The puncture tool housed in the handle would be withdrawn to perforate the protective cover and two membranes. Mixing components A and B could be accomplished when the entire device is applied with a slight twisting motion to the target area.

Concept No. 2 contains adhesive components A and B in a plastic bag. Mixing is achieved in the open neck area after the separator has been broken. The material would then be forced out the neck opening. This concept would probably be best suited for repair work.



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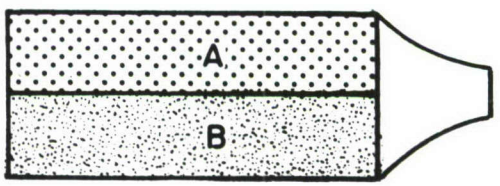

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